ERIC Document Resume | See Instruction Sheet | DATE OF RESUME 6/28/65 | DATE RECEIVED

A. PUBLICATION DATA

1. ERIC NUMBER: ED000783 | 2. ORIGINATOR CONTROL NO(S).: 8227 | 3. IDENTIFICATION NO.:

DO NOT WRITE IN SPACE BELOW

4. AUTHOR(S):
Skillings, H. Hills

5. TITLE OF DOCUMENT ABSTRACTED:
Manual for Computer Class Scheduling:
Mechanics of Operation at the University of Massachusetts

MICROFILM COPY AVAILABLE YES ☒ NO ☐

COPYRIGHT GRANTED YES ☐ NO ☒

COPYRIGHT RELEASE FILED YES ☐ NO ☐

6. PUBLICATION TITLE:
N.A.

TYPE OF REPORT
PROPOSAL ☐
IN-PROGRESS ☐
FINAL ☒
FOLLOW-UP ☐

7. EDITOR(S):
N.A.

8. PLACE OF ORIGIN
ORG. Univ. of Mass.
ST. Amherst, Mass.
CITY, STATE
TELE. EXT.
INST/LOC CODE

OTHER ERIC REFERENCES:

9. PUBLISHER OR SOURCE
University of Massachusetts

10. VOL.	11. PAGES	12. MO./YR.	13. TOTAL PP.
N.A.	N.A.	Apr. 63	18

ERIC SATELLITE CODE

B. INDEXING DATA

14. SUBJECT AREA

15. TYPE OF ENDEAVOR
manual

16. INDEXING TERMS (6-12)

manuals	information retrieval			
data processing	scheduling			
information storage	administration			

17. ABSTRACT (MAX. 250 WORDS)

In this second publication on the use of computer class scheduling at the University of Massachusetts, steps in the scheduling procedure are explained in detail from the point where the student and his faculty adviser select the student's courses to final registration when the student receives his semester schedule. The first paper in the series dealt with the general objectives of the process. Additional copies of this report may be obtained as long as the supply lasts from the Office of Institutional Studies, University of Massachusetts, Amherst, Mass.

ERIC No.

18. SOURCE OF ABSTRACT

C. FUNDING DATA

19. SUPPORTING ORGANIZATION

20. DIVISION OR DEPT.

21. CONTRACT NO.
PROJECT NO.

22. TOTAL COST OF PROJECT

23. DURATION OR PROJECT

U.S. Department of Health, Education, and Welfare
Office of Education

ERIC Form 1

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MANUAL FOR COMPUTER CLASS SCHEDULING:

Mechanics of Operation at the University of Massachusetts

H. Hills Skillings

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Office of Institutional Studies
University of Massachusetts
Amherst, Massachusetts

ED 000783

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EP 000278

MANUAL FOR COMPUTER CLASS SCHEDULING:

MECHANICS OF OPERATION AT THE UNIVERSITY OF MASSACHUSETTS

H. HILLS SKILLINGS
Assistant Professor of Mathematics
and
University Scheduling Officer

Office of Institutional Studies
Information Series - Number 6
April 1963

Additional copies of this report may be obtained from the
Office of Institutional Studies, University of Massachusetts,
Amherst

FOREWORD

This is the second publication on the subject of computer class scheduling as it is accomplished at the University of Massachusetts. The first paper, "Computer Class Scheduling: Experience at the University of Massachusetts", dealt with the general objectives of the process. In this new manual, Professor Skillings explains the detailed steps in the scheduling procedure, from the point where the student and his faculty adviser select the student's courses to final registration when the student receives his semester schedule.

The response to the first paper was most gratifying. The numerous inquiries as to various details of the process have indicated that the manual may be of interest to institutions which are exploring computer class scheduling. The 7090 program (see page 12 of this paper) based upon a program originally developed by Purdue University and IBM in 1960, with listings and operating instructions, is available through IBM. Inquiries should be addressed to IBM Corporation, Room 26-147, 77 Massachusetts Avenue, Cambridge 39, Massachusetts.

While no one set of operating instructions will fit the individual needs of all institutions, an exchange of ideas will profit all. Professor Skillings will welcome comments, suggestions and inquiries on the material presented in this paper.

Leo F. Redfern, Director
Office of Institutional Studies

Amherst
April, 1963

INTRODUCTION

The process of registering students for classes at the University of Massachusetts may be separated into five steps. These are, in chronological order:

1. preparation of a master schedule of courses and sections being offered;
2. preregistration of the students;
3. assembly of students decks, summary of course enrollments, and amendment of the master schedule;
4. computer scheduling; and
5. final registration.

While these steps are decidedly interdependent, the following discussion will be more orderly if they are treated separately.

THE MASTER SCHEDULE

The master schedule of class offerings for a semester is prepared in time to be available for preregistration. The schedule lists the courses that will be offered, detailing the sections within each course and including, for the majority of sections, the time and place of meetings. A few courses are listed as "By arrangement". Essentially such listing is restricted to those courses where a small enrollment (5 - 10) is anticipated and the department prefers to establish convenient meeting times after consultation between the instructor and the students.

In general, year-to-year changes in semester schedules are moderate. The patterns which have evolved appear to minimize conflicts between courses and to promote departmental effectiveness. Effective space utilization is a major consideration in modifying the existing schedule as new courses are introduced (or as sections are added to existing courses) to accommodate increasing enrollments. This evolutionary process has proved more satisfactory than attempts at radical change made solely for the purpose of more efficient use of space.

SPRING SCHEDULE 1962-63 -1-

Cour No.	COURSE TITLE	Sec No.	LECT. TIMES	ROOM	Lab. No.	LAB. TIMES	ROOM
	AGRONOMY		AGRON				
22	Soils	1	8-9 TuTh	S 102	1	3-5 W	S 114
52	Forage Crops	1	8-9 MWF	S 114			
59	Soil Plan Min Nutri	1	8-9 TuTh	S 114	1	1-3 Th	S 19
84	Soil Chem	1	By Arrgt				
98	Spec Prob	1	By Arrgt				
264	Exp Meth in Agron	1	By Arrgt				
	ANIMAL SCIENCE		AN SCI				
52	Feeds & Feeding						

Figure 1 — Sample Excerpt of the Master Schedule

The completed master schedule is reproduced in pamphlet form in sufficient quantity to provide for distribution to each student, to each member of the faculty, to appropriate administrative offices and in quantity to the registrars of the other members of the Four-College Cooperative Program (Amherst, Mount Holyoke and Smith).

PREREGISTRATION

Each semester there is a Counseling Day on which the students meet with their faculty advisers to discuss academic programs and to select the courses which the student will take in the following semester. In order that students and faculty may concentrate attention on this project, no classes are scheduled on Counseling Day (which is early in May for the fall term and early in December for the spring term). It has been found that there is greater convenience for all concerned under this practice than under the former policy of conducting preregistration over a full week, during which classes were continued as usual.

In selecting his courses, the student must check the master schedule to make certain that there is at least one combination of courses which can be scheduled without a conflict of meeting times. If a nonconflicting combination of desired classes is impossible, the selection of courses must be revised. The student enters his final selection of courses on a registration card and the adviser signs the card indicating approval of the selection.

Figure 2 — Registration Card

A student's request to be assigned to a *particular section* may be accommodated if (a) he files with the Schedule Officer an authorization for a special schedule, certified by the Dean of Men or Dean of Women, or if (b) he registers for a course where the department has indicated that it wishes to have such requests accommodated. (The computer program contains provisions for specifying assignment to a particular section.) Otherwise, student requests for specific section assignments are disregarded.

The completed registration cards are returned to the Office of the Registrar where a record is kept of those which have been filed. Students whose cards are not returned by the announced deadline receive notice that the University assumes that they are planning not to return in the next semester. Such notice usually secures the prompt return of the majority of the missing cards! Further checking is required for those few still unreturned before they are declared not enrolled.

The registration cards are then turned over to the Scheduling Officer for processing. This occurs approximately two weeks after Counseling Day.

ASSEMBLY OF STUDENT DECKS

For each registration card, the staff of the Schedule Office assembles a "student deck" consisting of a permit card to identify the student and request cards to identify each phase of each course requested.[1]

The students decks are assembled by hand from trays containing the request cards. These have been prepared in bulk according to estimates of the number of registrations for, or the physical limitations of, the individual courses. Additional request cards can, of course, be prepared to meet unexpected demand if the department has the staff and physical facilities to provide for the larger enrollment. Experience indicates that the average student deck (numbering seven request cards) can be assembled and checked at the rate of twenty to twenty-five per man-hour.

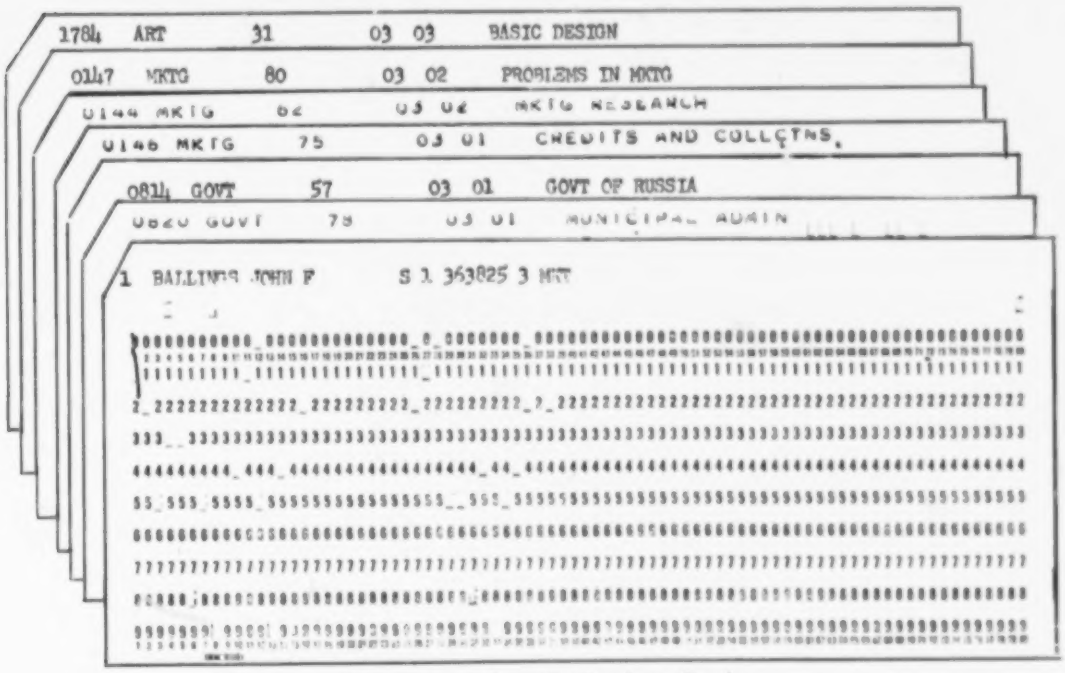

1784 ART 31 03 03 BASIC DESIGN
0147 MKTG 80 03 02 PROBLEMS IN MKTG
0144 MKTG 62 03 02 MKTG RESEARCH
0146 MKTG 75 03 01 CREDITS AND COLLCTNS.
0814 GOVT 57 03 01 GOVT OF RUSSIA
0820 GOVT 78 03 01 MUNICIPAL ADMIN
1 BALLINGS JOHN F S 1 363825 3 MKT

Figure 3 — Sample Student Deck

[1] The format of these cards is discussed in the IBM 7090 Class Scheduling Program (see Foreword).

For the assembly procedure at the University of Massachusetts the bulk request cards are filed alphabetically by department identification in card trays. The cards for the various courses are separated by dividers with tabs on which the identification of the course is visible. The trays are designed to store the cards on end (as opposed to horizontally) in order to minimize the area required. Thirty to thirty-five trays are required at the University to hold the request cards for the 700 courses available to 6000 students.

The trays are spaced around a rectangular table approximately six by eight feet in area and three feet high (to aid standing workers). The assemblers move around the table to collect the cards for a student deck. This has proved more efficient than having the assemblers, stationed in fixed positions, pass the decks from one person to the next.

As the supply of cards is reduced the remaining cards are consolidated into fewer trays and the empty trays are then used for filing the completed request decks.

It has been found expedient to represent courses which involve multiple sections in both the lecture and the laboratory phases of instruction by separate request cards for purposes of conserving core storage in the computer. The illustration below indicates that six storage positions are required for a combined listing of a course consisting of two lecture and three laboratory sections, whereas only five storage positions are required for the separate listing:

Combined Listing	*Seperate Listing*
One Request Card	*Two Request Cards*
Lecture 1, Laboratory 1	Lecture 1
Lecture 1, Laboratory 2	Lecture 2
Lecture 1, Laboratory 3	
Lecture 2, Laboratory 1	Laboratory 1
Lecture 2, Laboratory 2	Laboratory 2
Lecture 2, Laboratory 3	Laboratory 3

This saving of core storage positions is most significant in courses such as elementary chemistry which offers ten sections each in lecture and laboratory. This requires only twenty separate listings as opposed to one hundred listings needed under a combined system.

After a deck is assembled and checked, the registration card is separated and the deck (with the permit card first, followed by the request cards) is filed in a tray. At this stage in the process it is imperative that this order of permit card-request cards be undisturbed because there is no other way of identifying request cards with permit card until the former are code punched with the student number. As trays are filled they are immediately processed by having the student number in the permit card punched in the request cards as a safeguard for future handling.

No attempt is made at this stage to preserve alphabetic order among the student decks. This is primarily because assemblers work at different speeds with the result that any initial sequence has been lost at the end of the assembly process.

The assembly staff, composed of part-time student labor, consists of one person to make an initial check of the registration card for obvious errors and special requests, one person to check the completed student decks, and four or five persons to do the actual assembling of the decks. The space available in the assembly area dictates the optimum number of workers. Considerable mental concentration is required by the staff. They must be alert to include all of the multiple cards for laboratory courses, to make certain that a man is not given a woman's physical education card, to select the correct request card in those courses where some sections are designated for departmental majors and other sections for non-majors, and similar sorting. It is desirable, therefore, to work only in short periods separated by reasonable breaks. The timing depends, of course, upon the calibre of the individuals employed.

When all of the registration cards have been processed and the student decks assembled and punched with the student numbers, the cards are machine sorted by student number to produce an alphabetical sequence. The permit card (identified by code "1" in column 1) is collated ahead of the appropriate set of request cards (identified by code "2" in column 1).

All of the cards are then recorded on magnetic tape by the IBM 1401. A by-product of this process is a printed listing of: (1) students who have registered for less than a minimum or more than a maximum number of credits, (2) student decks lacking permit cards or having no request cards, (3) student decks having duplicate request cards and (4) student decks having an improper card type. These matters are then rectified.

A listing of the tape is then printed for use as an additional check on the accuracy of the student decks. This listing is compared with the original registration card entries and, again, any mistakes are corrected.

The information on the tape is then sorted by a 1401 computer program to produce course rosters which list student name, number, class in college and major field, and give a tally of the total course enrollment. These rosters provide the opportunity for another check on the accuracy of the student decks. Specifically, the total enrollment in the lecture portion of a course must agree with that in the laboratory portion of the course, or an English major's name should be checked when it is listed in a course restricted to majors in engineering.

It is appropriate to digress for a moment in explaining the amount of time spent on checking and rechecking the accuracy of the assembled student decks. The final product of the computer scheduling operation is completely dependent upon the accuracy of the input information. Computer scheduling is a radical departure from time honored processes and, as such, is subject to some conservative resistance. In the interests of public relations, if not of administrative efficiency, it is deemed to be most important that every effort be made to detect and correct as many of the human errors as possible. As the computer scheduling operation becomes more of a habit than a venture, improved and more efficient methods of checking will be developed. But, until they are, any step that increases accuracy will be taken as worth the time that it requires.

Returning to the scheduling operation, departments are notified of the figures on total enrollments for the various courses. It is at this stage that the master schedule of classes may be amended to add or delete sections in order to adjust to the demand on courses. Also at this time changes are made to adjust for the unforeseen availability or unavailability of faculty to staff a department's course offerings. It is one of the objectives of the computer scheduling process that this step be delayed as late as possible, prior to the beginning of the semester, in order that as many changes as possible may be accommodated in the computer run. This will reduce changes at, and subsequent to, final registration.

Beginning on the day following Counseling Day, students may report with requests to change their elections. They are required to file a form, signed by their adviser, indicating the change which they wish. After the student decks have been assembled, and as time permits, these requests are accommodated by removing and adding appropriate cards in the student decks. This will affect the enrollment figures as initially reported to the departments, but it has been found that these changes are rarely of significant magnitude in any one course. Because of the closeness in the timing of operations it has not been possible to accomplish all of the changes requested by students. Those students who are not accommodated have an opportunity to make the change on Registration Day by dealing directly with the departments concerned.

COMPUTER SCHEDULING

The principal phase of the University's computer scheduling operation requires an IBM 7090 computer. Because the University does not yet have such computers, time is rented on one at a commercial service center.

The input for the computer consists of (a) the program on punched cards, (b) the course and section data on magnetic tape and (c) the student request information on magnetic tape.

The course and section data file, on cards, was prepared from the master schedule prior to the preparation of the bulk request cards. Because certain information on the request cards is derived from the course and section data file, it is necessary that the latter be prepared first. It is expected that a program will be developed soon which can replace this information on the request card by a "look-up" procedure on the University's 1401. This will permit greater flexibility in adjusting the course and section data file to the changes made by departments subsequent to publication of the original master schedule.

In adjusting the course and section data file to section changes, the deletion of a section is accomplished by recording the section as having a zero seating capacity. The addition of a section, if prior provision was not made, involves an appreciable amount of time as the individual request cards already in student decks to represent the course in question must be replaced with new ones which reflect the change in course and section data cards. The course rosters (discussed in the section on SUMMARY OF ENROLLMENTS) are used to identify the students involved. Each student deck has to be located, the proper card withdrawn and a replacement, coded with the student's number, inserted, and the set returned to its proper place in the file. The opportunities for human error are many! It is desirable that the initial course and section data file be developed with as much consideration as possible for these "unforeseen" contingencies. This is done by providing dummy sections for later possible use in those courses where the Scheduling Officer feels that the department may have underestimated enrollment. A dummy section is one for which no time or place of meeting is specified and which is listed as having no seating capacity. The computer program will not assign any students to a section having zero seating capacity. By altering the designation of seating capacity and adding specification of time and place of meeting, a dummy section is converted to an active section.

A "look up" procedure on the 1401 would eliminate the need for exchanging request cards or using dummy sections and would facilitate materially the process of amending the master schedule.

The course and section data cards and the student decks are recorded on magnetic tape because the latter is a much faster means for input to the computer.

The timing of the computer (7090) run prior to final registration depends upon the other demands in the same period on the University's 1401. For the fall term, 1962, the time table was:

first day — record the course and section data and the student request files on magnetic tape

second day — scheduling run on the 7090, output on magnetic tape

third day — 1401 print-out of the schedules produced by the 7090

fourth day — 1401 sort of the schedules to produce section rosters

fifth day — 1401 print-out of the rosters

sixth day — available for emergencies

seventh day — Registration Day.

For the spring term, 1963, eight days were required because of added demands upon the 1401 (compilation of fall term grades, first-of-the-month payrolls, etc.) which were not present in the second week of September.

First Day: Separate tape reels are used for the course and section data file and the student request files. The student request decks are recorded with approximately 1500 per tape reel to minimize loss in the event of tape problems. The card files are taken along with the tape reels to the 7090 location as back-up information in the event of tape failure.

Second Day: The total time required on the 7090, for the complete processing of 6000 student schedules, is approximately an hour and a half. The actual production of one student schedule averages slightly less than half a second. No other steps in the scheduling operation are planned on the second day because of the travel time involved in going to the computer. (With regard to obtaining details on the 7090 class scheduling program, see Foreword.)

Third Day: The first listing printed from the 7090 output is the list of "rejects"; i.e., students for whom schedules were not developed either because their requests could not be scheduled without a conflict or because the computer did not develop a workable schedule within the maximum number of tries set by the program. Conflicts arise because of careless selection of courses (the student did not check the schedule when

choosing his courses) or result when a department finds it necessary to change the time of an offering. A maximum number of tries (1000 in the University's program) is set to avoid wasting computer time on fruitless search in complicated schedules. A "try" consists of testing a certain section for compatibility with the student's previously assigned sections.

In scheduling for the spring semester, 1963, of the approximately 6200 schedules attempted, 185 (3%) resulted in conflicts and 61 (1%) were rejected because of the 1000 try limit. It is of interest to note that these 61 schedules were rerun with the limit on tries raised to 10,000 with the result that 34 were successfully scheduled.[2]

The rejected students are scheduled "by hand" in the Schedule Office. In developing these schedules, the conflict is detected and one of the courses involved is dropped from the student's program in order to minimize his difficulties at Registration. A schedule form is typed for him, but his name is not added to the section rosters that are prepared by the 1401.

The second listing from the 7090 output is the "redump" which indicates the number of unused seats remaining in each section of each course. This information is used in the scheduling of the rejects in order not to overload sections.

The third listing from the 7090 output is the individual student schedules, printed individually on three-part forms. The student receives one of these forms at Registration, the second is filed with the Registrar and the third is sent to the student's adviser.

363825 BALLINGS JOHN F 3 MKT

SUBJ	COURSE	SEC	CLASS TIMES	BLDG	ROOM	CREDITS
GOVT	78	1	TUTH 1-2.30	SK	AUD	3
GOVT	57	1	MWF 3-4	ED	AUD	3
MKTG	75	1	MWF 9-10	DRA	117	3
MKTG	62	1	MWF 11-12	DRA	117	3
MKTG	80	1	MWF 8-9	DRA	117	3
ART	31	2	TUS 10-12 TH 10-11	B	225	3

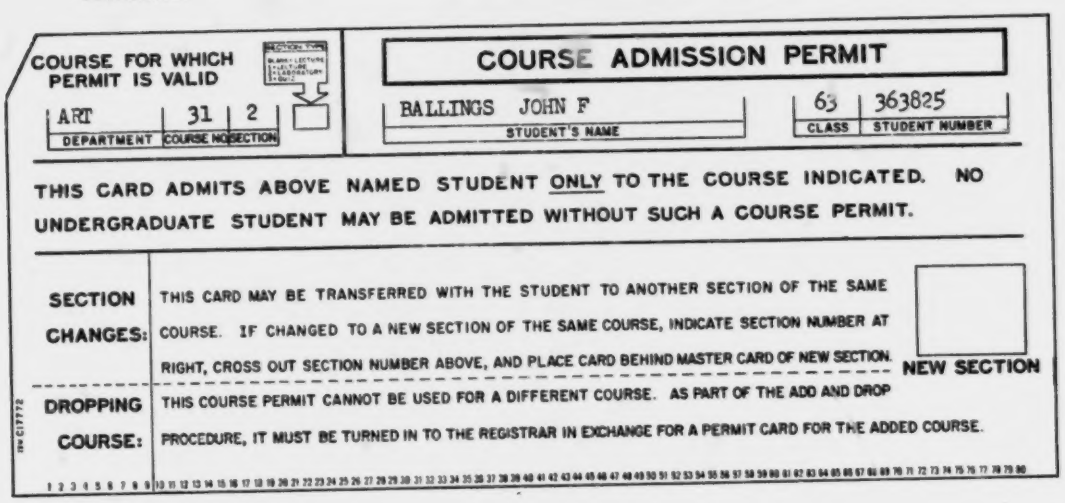
TOTAL CREDITS 18.0

Figure 4 — Sample Student Schedule Form

[2] No firm figures have been developed to weigh the added time that would result from using the 10,000 limit for the full scheduling run on the 7090.

Fourth Day: The computer program which is used on the 1401 to develop section rosters from the individual student schedules is the standard Sort 1 for the machine. This day is also used in the hand-scheduling of the rejected students. It is estimated that these schedules for rejects are produced at the rate of three per man-hour.

Fifth Day: The section rosters are printed on three-part forms, of which two go to the department concerned and one is retained by the Schedule Office. Individual course admission permits are also produced from the sorted listings. These are sent to the departments, with the rosters, and are used as the basis for reporting final student registrations to the Registrar. The use of course admission permits was introduced in January, 1963, and their effectiveness has not been evaluated yet. These permits will be used as the basis for preparing grade cards which will be issued to instructors for reporting student grades at the end of the semester.


COURSE FOR WHICH PERMIT IS VALID

DEPARTMENT	COURSE NO	SECTION
ART	31	2

COURSE ADMISSION PERMIT

STUDENT'S NAME	CLASS	STUDENT NUMBER
BALLINGS JOHN F	63	363825

THIS CARD ADMITS ABOVE NAMED STUDENT ONLY TO THE COURSE INDICATED. NO UNDERGRADUATE STUDENT MAY BE ADMITTED WITHOUT SUCH A COURSE PERMIT.

SECTION CHANGES: THIS CARD MAY BE TRANSFERRED WITH THE STUDENT TO ANOTHER SECTION OF THE SAME COURSE. IF CHANGED TO A NEW SECTION OF THE SAME COURSE, INDICATE SECTION NUMBER AT RIGHT, CROSS OUT SECTION NUMBER ABOVE, AND PLACE CARD BEHIND MASTER CARD OF NEW SECTION. NEW SECTION

DROPPING COURSE: THIS COURSE PERMIT CANNOT BE USED FOR A DIFFERENT COURSE. AS PART OF THE ADD AND DROP PROCEDURE, IT MUST BE TURNED IN TO THE REGISTRAR IN EXCHANGE FOR A PERMIT CARD FOR THE ADDED COURSE.

Figure 5 — Course Admission Permit

Sixth Day: While nothing specific was planned for this day originally, it was included in the time table to allow for emergencies. It was found that the time was needed to complete the sorting of schedules, rosters and permit cards for distribution.

REGISTRATION

Seventh Day: The students are required to report to a central location to receive their class schedules and to file certain forms incidental to final registration. If at this time they wish to change the program which they have been issued, they may contact the individual departments to accomplish such action. For this purpose, representatives of all the departments are established in another large room removed from the main registration area, but available to assist in making adjustments.

A student who does not wish to change his program can complete this final phase of registration in five minutes. Many, with valid reasons, go on to the second registration area to alter their programs. Too many, in the hope of obtaining a schedule that is personally more desirable, also report to the second area seeking program changes. There are no reliable figures on the number of students who do not seek to change their programs, but it is estimated that they would represent between sixty-five and seventy percent of the total. While this result is disappointingly low, it is an improvement over previous conditions when a far larger number of students did go to the departments to change programs.

With more experience, with greater consideration given by the student and his adviser to the initial choice of courses, and with increased resistance by departments to whimsical changes by a student, it is hoped that the percentage of changes can be reduced materially.

CONCLUSION

One report, which did not originate on this campus, stated that, "Electronic computers are taking the headache out of class scheduling at the University of Massachusetts". It would be more accurate to state that the computers are concentrating the headache in the Schedule Office instead of distributing it about the campus. It would be facetious to imply that computer scheduling is welcomed by all faculty and students, that the departments now have no headaches, or that computer scheduling in its present stage is at the point of ultimate perfection. Much remains to be accomplished in refinements and improvements. Greater consideration for individuals must be incorporated, more efficient means must be developed for assembling student decks and accommodating changes in courses and student requests, and more effective procedures must be found to record and process postregistration changes.

However, as its newness wears off, computer scheduling is meeting with less resistance. Even in its initial stages, the vast majority of department heads indicated that it was an improvement over previous methods. With the incorporation of an effective method for programming specific section assignments for those students who can substantiate their need for such, even the students are finding this procedure less offensive.

The prime purpose behind computer scheduling is the optimizing of class and student schedules to make the best use of faculty and facilities in order to provide the best education possible for large numbers of students. With the number of variables involved, man cannot think fast enough to match the computer's ability in this respect. The future will prove that today's efforts are crude, but everything must have a beginning. Progress made thus far will provide the building blocks for greater accomplishments in the future.

AVAILABLE PUBLICATIONS

INFORMATION SERIES

No. 1—Parents' Ability to Meet College Costs at the University of Massachusetts, February 1962.

No. 2—Chapter 648, Acts of 1962—An act relative to the administration of the University granting certain powers of self-management.

No. 3—Chapter 787, Acts of 1962—An act establishing a medical school within the University of Massachusetts.

No. 4—Chapters 108 and 145, Acts of 1962—Resolve providing for a study relative to improving and extending educational facilities in the Commonwealth.

No. 5—Computer Class Scheduling: Experience at the University of Massachusetts, December 1962.

No. 6—Manual for Computer Class Scheduling: Mechanics of Operation at the University of Massachusetts, April 1963.

No. 7—Electronic Data Processing of Admissions.

No. 8—Parents' Attitudes Toward Higher Education at University of Massachusetts (in process).

MISCELLANEOUS PUBLICATIONS AND STUDIES

Factors Involved in Considering Year Round Operation of Institutions of Higher Education, November 1961.

1962 Report of the Long Range Academic Planning Committee, submitted to the President and University Faculty, June 1962.

Digest of Recommendations Made in the 1962 Report of the LRAPC, October 1962.

Analysis of survey on allowable time for such things as consulting or contract research for which added compensation is received, at selected State and Land-Grant institutions, June 1962.

Distribution and Home Town Residence of Massachusetts Undergraduate Students enrolled at the University of Massachusetts, February 1962.

A report on the University of Massachusetts and Its Relationship with the Commonwealth, prepared by the Faculty Committee on Trusteeship and Faculty Salaries, January 1962.

Preliminary Enrollment Plans of Massachusetts Colleges and Universities, 1960-1975 (in process).

The above publications will be sent upon request at no cost while supplies last to other colleges and universities, bureaus of research, libraries, educational associations and similar organizations.